RESPONSE OF SAND SHINNERY OAK

TO SOIL APPLIED HERBICIDES

By

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CHAPTER I

INTRODUCTION

Sand shinnery oak, Quercus havardii, is the dominant vegetation on some 800,000 acres in western Oklahoma, 8,800,000 acres in Texas, and 5,000,000 acres in New Mexico. The greatest concentration in Oklahoma occurs on the Nobscot fine sands in Woodward, Ellis, Roger Mills, Beckman, and Harmon counties.

Sand shinnery oak is not a rapid invader of grasslands. It has not increased much in recent years, however stands have thickened. Once eradicated the plant does not reinvade areas rapidly.

The oak essentially shades out the herbaceous vegetation and in much of the sand shinnery oak areas, 90% of the total dry matter production consists of sand shinnery oak. Native grasses growing in association are less nutritious, fiber content is increased, and a lower sugar content exists which further decreases the usefulness of the range.

In addition, sand shinnery oak is poisonous to livestock during its flowering period, March to early April, which precedes new leaf formation. The poisonous substance in sand shinnery oak is a tannin. This substance exerts its effects in the intestional tract of livestock. The rumen will become tougher and thicker with results ending in death.

Control of sand shinnery oak with foliar applied herbicides have been successful in converting these areas into productive range sites. However, most of the foliar applied herbicides have not been effective in producing root kill of sand shinnery oak and respraying has been necessary to maintain the control of the oak plants. There are now some pelleted formulation of herbicides that are soil applied and which have given better root kill of brush species than the foliar sprays.

The objectives of this research were: (1) to evaluate control of sand shinnery oak with hexazinone, Vel 5026, and two formulations of picloram and tebuthiuron, (2) to determine what effects these herbicides have on forage production, and (3) to determine what effects these herbicides have on carbohydrate levels in the roots of sand shinnery oak.

CHAPTER II

LITERATURE REVIEW

Sand shinnery oak (common and scientific names of all plants reviewed are listed in Table 1) has a variety of growth forms varing from a small brushy stem to an extremely, well-foliated tree. The plant has an intensive root system consisting of both lateral and vertical roots. Pettit and Deering (17) estimated the root:shoot ratio of sand shinnery oak to be 10:1. One oak plant may have a continuous root system through 11 meters of soil. The larger vertical roots are basically nonfunctional for water and nutrient uptake and transport. The lateral roots are however better accomodated to absorb water and nutrients and move them throughout the plant. The lateral roots are also capable of sprouting along their entire length.

Sand shinnery oak occurs on soils with an extremely high percentage of sand. Apparently these sand deposits results after historical rivers, which traversed the plains became dry and blew into the areas (18). Sand shinnery oak flourishes in areas with an annual precipitation of 35 to 70 cm.

Control

Goats and fire were used in the early settlement days to control sand shinnery oak (10). Goats did not obtain widespread use or acceptance. McIlvain and Armstrong (12) noted that burning sand

Table 1. Common and scientific names of names of plants reviewed.

Common name	Scientific name
Blackjack oak	Quercus marilandica Muenchl.
Live oak	Quercus virginiana Mill.
Little bluestem	Andropogon scoparius Michx.
Post oak	Quercus stellata Wang.
Red lovegrass	Eragrostis oxylepis Torr.
Sand paspalum	Paspalum stramineum Nash
Sand shinnery oak	Quercus havardii Rydb.
Winged elm	Ulmus alta Michx.

shinnery oak increased stem density by 15%. Burning did however keep sand shinnery oak as a low growing shrub and prevented formation of acorns the year following the burn. They also found that burning will make sand shinnery oak more susceptible to a herbicide treatment.

Mechanical methods using mowers, beaters, cutters, and choppers have been unsuccessful for the control of sand shinnery oak. McIlvain (10) reported mowing in consecutive years and successive mowings within one year, often repeated for several years, had little effect in thinning the density of the oak stand.

Numerous studies have been carried out with the use of foliar applied herbicides to control sand shinnery oak. McIlvain (10) suggested a program of 2 to 3 consecutive years of spraying. Spraying should be done between May 15 and June 15 with 1.12 kg/ha of the low-volitile ester formulation of 2,4-D (common and chemical names of all herbicides mentioned are listed in Table 2). He found that 2 or 3 years of spraying resulted in a top kill of 100% and root kill of usually 80 to 90%.

Deering and Pettit (5), working with 2,4-D, 2,4,5-T and a mixture of 2,4,5,T amine and picloram, found that there was good top kill with these herbicides, however there was vigorous resprouting associated with the treatments. Scifres (22) indicated that a 0.56 kg/ha rate of silvex applied in a diesel oil:water emulsion (1:4) was the most effective treatment for reducing sand shinnery oak canopy and stem density. Canopy reduction of 90% was obtained by this treatment. Reduction in stem density was 70% after one year and 75% after the second year. This rate did not reduce sand shinnery oak regrowth from lateral root tissue.

Table 2. Common and scientific names of herbicides reviewed.

Common name	Scientific name
2,4-D	(2,4-dichlorophenoxy)acetic acid
2,4,5,-T	(2,4,5-trichlorophenoxy)acetic acid
Hexazinone	3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione
Dichloroprop	2-(2,4-dichlorophenoxy)propanoic acid
Monuron	3-(p-clorophenyl)-1, 1-demithylurea
Picloram	4-amino-3,5,6-trichloropicolinic acid
Silvex	2-(2,4,5-trichlorophenoxy)propinonic acid
Tebuthiuron	N/5-(1,1-dimethylethyl)-1,3,4,-thia-diazol-2-yl/-N, N'-dimethylurea

Upchurch et al. (27) provided a possible explanation for the fact that foliage treatments provide control for the existing stem but allow resprouts to occur. Herbicides enter through the leaves and move into the vascular system, which inturn moves the herbicides throughout the parts of the plant that are actively growing. Once in a specific site, the herbicide is effective in killing local tissue and as a result apical dominance is destroyed. New shoots then develop from dormant lateral buds and the herbicide concentration in these areas is too low to control these resprouts.

In Oklahoma, 2,4,5-T, silvex, and dichloroprop at 1.12 kg/ha have been the major foliar applied herbicides used for control of sand shinnery oak. Applications should be made in June when leaves are fully open and should be applied only in years when growing conditions are favorable (1).

Soil Applied Herbicides

Meadors et al. (14) suggested using pelleted formulations of monuron applied to the soil for control of sand shinnery oak. They found that monuron applied as a pellet had good activity on the oak. Stem kill of 50% was obtained and activity was still evident 3 years after application. Grass injury was less with the pelleted formulation of monuron than with the wettable powder formulation.

Tebuthiuron, a substituted urea type herbicide similar to monuron, has shown promise for oak brush control in Oklahoma. Nickels and Stritzke (16) in southeast Oklahoma noted 86% tree kill of post oak with both 1.12 and 2.24 kg/ha rates of tebuthiuron. In the same study, tree kill of blackjack oak was 86% with the 2.24 kg/ha rate of tebuthiuron.

Jones (8) observed in Texas that 93% of sand shinnery oak stems were killed by a 1.12 kg/ha rate of tebuthiuron. Similar results were obtained by Pettit (19) with the same rate of tebuthiuron.

Picloram is a pyridine derivative compound (7). Bovey et al. (3) found that picloram could effectively control live oak. Scifres (20) found that a 2.24 kg/ha rate of picloram pellets was required to reduce the density of sand shinnery oak stems one year after application. Jones (8) noted that 90% of sand shinnery oak stems were killed by 2.24 kg/ha rate of picloram pellets.

Soil applied herbicides should be applied prior to the rainy season. An application at this time would insure activation of herbicide. McNeil et al. (13) noted pelleted formulations allow for more stability on a soil surface. This allows the herbicide to remain on the surface for considerable lengths of time without significant loss of herbicide activity. Shipman (23) examined other considerations of a soil applied herbicide. He found that soil applied herbicides have a lower order of toxicity to man and animal, soil applied herbicides require no elaborate mixing and produce a high level of control with a low level of resprouting. They also have the advantage of not being subject to drift to areas of susceptible crops.

However, soil factors play an important part in the effectiveness of a pelleted herbicide. Kitchen and Scifres (9) attributed poor woody plant control to clay pans 30 to 40 cm deep. These clay pans prevent downward movement of picloram to deep roots. Fischer and Stritzke (6) working with tebuthiuron reported that as clay content of a soil increases tree kill decreases.

Grass Release

There is usually a significant increase in herbaceous plant production with brush control. Control of woody plants brings about a release of available minerals, moisture, and sun light. Sosebee (25) noted that in herbicide treated areas, herbaceous plants are often greener, more vigorous, and more productive. Water content of treated plans is usually significantly higher than in untreated plants.

McIlvain and Armstrong (11), working with foliar herbicides, noted that a 10% kill of sand shinnery oak stems doubles forage production. They also reported a 20% kill would triple forage production. Scifres (21) found that grass production was 6 times the control when a combination of 2,4,5-T and picloram at 1.12 kg/ha was used to control sand shinnery oak.

Picloram and tebuthiuron pellets differ in their grass release capabilities. Pettit (19) reported that picloram pellets at 7 kg/ha dramatically increased forage production. Meadors et al. (15) observed that native grasses were not detrimentally effected by picloram pellets. Pettit (19) noted detrimental effects from picloram pellets. Pettit (19) noted detrimental effects with tebuthiuron. A 3 kg/ha rate of tebuthiuron essentially "cleaned out" a plant community. Many of the forbs were killed and perennial grasses such as little bluestem, red lovegrass, and sand paspalum were injured. False buffalograss, a less desirable species, dominated the tebuthiuron plots.

Sosebee (25) found that there was a first year forage reduction but a good recovery of the grass plants one year after treatment. Stritzke (26) also reported that a 4.4 kg/ha rate of tebuthiuron damaged native grasses. By the second year however, forage production was increased by 100% in areas receiving 1.12 kg/ha and 200% in areas receiving 2.24 and 4.48 kg/ha of tebuthiuron.

Root TNC Levels

The amount of carbohydrate reserve in most perennial plants follow an annual cyclic pattern. Carbohydrate reserves increase to a peak in the fall and decline during the winter reaching a low with leaf expansion in the spring. Coyne and Cook (4) noted that stage of growth is the most important factor influencing carbohydrate concentrations in perennial plants. It would stand to reason then, that if a plant was disrupted at a particular critical stage of growth, the carbohydrate reserves would be altered for the remainder of the growing season.

Boo and Pettit (2) shredded sand shinnery oak with a power-take-off driven "flail-type" shredder. They found that the root carbohydrates were significantly reduced for about 6 months. This however, was only a temporary effect and root carbohydrate reserves were essentially the same as the control plants after 6 months.

Shroyer et al. (24) found that tebuthiuron was more effective than 2,4,5-T in reducing the percent total nonstructural carbohydrate levels (%TNC) in the roots of both blackjack and winged elm. There was also better defoliation of existing stems and better tree kill with tebuthiuron.

CHAPTER III

METHODS AND MATERIALS

Two studies were initiated in 1978, near Sharon, Oklahoma, to determine the effect of various pelleted formulations of picloram and tebuthiuron on sand shinnery oak and herbaceous vegetation. The Sharon, Oklahoma, area is a mixture of both tall and short grasses infested with sand shinnery oak of various sizes and densities. Common and scientific names of vegetation evaluated are listed in Table 3.

The first study, an aerial study, was applied by a Pawnee plane with a special pelleted herbicide applicator. Application was made on March 14, 1978. See Table 4 for a list of treatments used for aerial study. The experimental design for this study was a randomized complete block design with three replications. Each replication was located on a different cooperator. The Hamilton area was 25.7 km west, 6.4 km south, and 3.2 km northeast of Sharon. The Stevens area was 4.8 km west and 0.8 km south of Sharon. The Mote area was 6.4 km south, 3.2 km west, 3.2 km south, and 0.8 km west of Sharon. Each treatment was assigned to a 1179 m by 154 m plot at both the Hamilton and Stevens areas. The Mote area plot size was 845 m by 154 m.

The second study initiated in 1978 was on the Stevens ranch adjacent to the aerial plots. This study was applied with a cyclone seeder. Applications were made on March 16, 1978. See Table 5 for

Table 3. Common and scientific names of plants evaluated.

Common name	Scientific name	Abbreviation
Blue gramma	*Bouteloua gracilis* (Willd.) Lag.	Bgr
Little bluestem	*Andropogon scoparius* Michx.	Asc
Sand bluestem	*Andropogon hallii* Hack.	Aha
Sand dropseed	*Sporobolus cryptandrus* (Torr.) Gray	Scr
Sand lovegrass	*Eragrostis trichodes* Nutt.	Etr
Sand paspalum	*Paspalum stramineum* Nash	Pst
Sand shinnery oak	*Quercus Havardii* Rydb.	
Switchgrass	*Panicum virgatum* L.	Pvi

Table 4. Treatments used in the 1978 aerial study.

Treatments	ai	Pellet size	Rate
	(%)	(mm)	(kg/ha)
Picloram	10	4.0	1.12
Picloram	10	4.0	2.24
Picloram	5	4.0	1.12
Picloram	5	4.0	2.24
Tebuthiuron	20	3.2	0.56
Tebuthiuron	20	3.2	1.12
Tebuthiuron	20	1.6	0.56
Tebuthiuron	20	1.6	1.12

treatments used in this hand broadcast study. The experimental design for this study was a randomized complete block design with three replications. Each treatment was applied to a 30.5 m by 30.5 m plot.

Two additional studies were located on the Dewald area located 0.8 km west and 0.8 km south of Woodward Cemetery. The Dewald I study was applied June 1, 1979, and the Dewald II study was applied May 1, 1980. Both studies were applied by a cyclone seeder. Treatments used are listed in Table 6. The experimental design for both studies was a randomized complete block design with three replications. Each treatment was assigned to 30.5 m by 30.5 m plot.

The 1978 study areas are dominated by a loamy, mixed, Thermic Arenic Paleustalfs. Both of the Dewald studies are dominated by a sandy, mixed, Thermic Psammentic Haplustalfs. Physical properties for the soils at the Stevens and Dewald sites are given in Table 7. Permeability is rapid for both soils. A cover crop is needed at all times for protection against wind erosion.

Rainfall data for all studies was recorded at the Southern Great Plains Research Station located southwest of Woodward and is listed in Table 8.

Control Data

Sand shinnery oak defoliation and canopy reduction readings were taken on all studies. Defoliation is the amount of leaf kill determined the fall after an application in the spring or early summer. Canopy reduction is the amount of branch kill determined one or more years after a herbicide application. Stem kill and resprout data were taken along with canopy reduction. If a stems canopy is totally

Table 5. Treatments used in the 1978 hand broadcast study.

Treatment	ai	Pellet size	Rate
	(%)	(mm)	(kg/ha)
Picloram	10	4.0	1.12
Picloram	10	4.0	2.24
Picloram	5	4.0	1.12
Picloram	5	4.0	2.24
Tebuthiuron	20	3.2	0.56
Tebuthiuron	20	3.2	1.12
Tebuthiuron	20	1.6	0.56
Tebuthiuron	20	1.6	1.12
Vel 5026	10	4.8	0.56
Hexazinone	15	10 by 30	0.56

Table 6. Treatments for the 1979 and 1980 hand broadcast studies.

Treatments	ai	Pellet size	Rate
	(%)	(mm)	(kg/ha)
	1979 Hand Broadcast Study		
Picloram	10	4.0	0.56
Picloram	10	4.0	1.12
Picloram	10	4.0	2.24
Picloram	10	2.4	0.56
Picloram	10	2.4	1.12
Picloram	10	2.4	2.24
Tebuthiuron	20	3.2	0.28
Tebuthiuron	20	3.2	0.56
Tebuthiuron	20	3.2	1.12
Hexazinone	10	10 by 30	0.56
	1980 Hand Broadcast Study		
Picloram	10	4.0	0.56
Picloram	10	4.0	1.12
Picloram	10	4.0	2.24
Tebuthiuron	20	3.2	0.56
Tebuthiuron	20	3.2	1.12
Tebuthiuron	20	3.2	2.24
Tebuthiuron	10	3.2	0.56
Tebuthiuron	10	3.2	1.12
Tebuthiuron	10	3.2	2.24
Hexazinone	10	10 by 30	1.12
Hexazinone	10	10 by 15	1.12

Table 7. Physical properties for soil in study areas.

Depth	Sand	Silt	Clay	pH	Organic Matter
(cm)	(%)	(%)	(%)		(%)
	Stevens 1978 studies				
0-15	87	5	8	6.05	1.50
190-205	84	6	10	6.04	0.02
	Dewald 1979 and 1980 studies				
0-15	80	10	10	6.32	1.70
190-205	88	2	10	7.02	0.02

Table 8. Rainfall data.

Date	Centimeters	Date	Centimeters
1978			
Jan. 16	0.34	May 27	4.43
Jan. 26	0.08	May 28	4.72
Feb. 1	0.08	June 2	1.70
Feb. 7	0.74	June 3	0.08
Feb. 9	0.81	June 5	4.65
Feb. 13	1.17	June 6	0.33
Feb. 15	0.28	June 18	1.73
Feb. 17	0.13	July 7	0.38
Feb. 21	0 18	July 14	0.13
Feb. 28	0.03	July 19	6.48
Mar. 2	0.08	Aug. 3	1.30
Mar. 15	0.53	Aug. 4	0.51
Mar. 16	0.10	Aug. 9	0.25
Mar. 24	0.05	Aug. 10	0.25
Apr. 2	0.38	Aug. 11	0.25
Apr. 4	0.08	Aug. 28	0.94
Apr. 10	2.49		
May 1	0.74		
May 3	2.13		
May 4	0.46		
May 5	0.13		
May 6	0.25		
May 7	0.94		
May 18	0.69		
May 20	0.38		
May 22	0.74		
May 26	3.76		

Table 8. (Continued)

Date		Centimeters	Date		Centimeters
	1979				
Feb.	6	0.03	June	10	1.40
Feb.	7	0.10	June	22	1.85
Feb.	17	0.13	June	23	0.30
Feb.	21	0.03	June	24	1.02
Mar.	3	1.02	June	25	0.08
Mar.	18	6.30	July	2	0.56
Mar.	21	1.02	July	10	0.05
Mar.	22	4.04	July	14	0.10
Mar.	23	0.48	July	16	1.17
Apr.	1	1.57	July	17	6.30
Apr.	3	0.08	July	23	1.37
Apr.	10	0.15	July	24	2.84
Apr.	11	0.61	July	25	1.42
Apr.	18	0.05	July	31	1.60
Apr.	29	0.76	Aug.	15	0.64
May	1	0.15	Aug.	20	0.30
May	2	1.96	Aug.	25	1.42
May	3	0.48	Aug.	27	0.08
May	4	0.50	Aug.	31	0.10
May	10	7.06	Sept.	14	0.10
May	18	0.91	Sept.	15	0.13
May	20	0.97	Oct.	30	11.40
May	21	4.71	Oct.	31	0.61
May	22	0.25	Nov.	2	0.05
May	24	0.48	Nov.	8	0.08
May	31	0.25	Nov.	9	0.79
June	1	0.38	Nov.	10	0.13
June	2	0.36	Nov.	11	0.15
June	9	2.54	Nov.	20	0.03

Table 8. (Continued)

Date	Centimeters	Date	Centimeters
1979			
Nov. 21	0.05	May 5	0.30
Dec. 24	0.08	May 7	1.82
Dec. 28	0.53	May 8	0.48
Dec. 29	0.03	May 15	1.12
1980		May 16	4.28
Jan. 3	0.25	May 18	1.17
Jan. 19	1.09	May 20	0.89
Jan. 20	0.91	May 21	0.94
Jan. 21	1.17	May 27	1.04
Jan. 27	0.03	May 28	5.00
Jan. 29	0.03	May 29	0.33
Jan. 30	0.05	June 5	0.23
Feb. 8	2.06	June 9	0.41
Feb. 24	0.10	June 17	0.18
Mar. 12	1.04	June 18	0.08
Mar. 23	0.48	June 20	0.91
Mar. 24	1.60	June 22	3.68
Mar. 27	0.05	July 3	0.15
Mar. 28	1.45	July 21	0.56
Mar. 29	0.58	Aug. 11	0.08
Mar. 30	0.94	Aug. 15	1.73
Apr. 1	0.15	Aug. 16	0.41
Apr. 2	0.10	Aug. 23	0.08
Apr. 3	1.55	Sept.27	0.18
Apr. 24	3.89	Sept.28	0.79
Apr. 25	1.55	Sept.29	0.05
Apr. 26	4.65	Nov. 14	0.58
Apr. 30	0.10	Nov. 15	0.13
May 1	0.38	Nov. 24	0.05
		Nov. 25	0.38

reduced, the stem was dead. If this dead stem regrows at the base, the stem was listed as resprouting.

Defoliation, canopy reduction, stem kill, and stem resprout readings were taken by examination of individual stems within a plot. The number of observations vary with the size of the plot. On aerial plots 120 stems per plot were evaluated, whereas only 60 stems per plot were evaluated in the hand broadcast plots.

Grass Release

Grass yields were taken on both of the 1978 studies. First year forage production was measured on the aerial study only. Yields were determined by the use of 60, 29.21 cm by 60.96 cm, quadrats in the aerial plots and 10 quadrates in the hand broadcast plots.

Within each quadrate, the grasses were separated into species and weighed. Moisture content was determined for each species and forage production is reported on a dry matter basis.

Nonstructural Root Carbohydrates

Six roots 15 cm long by 1 cm in diameter from live sand shinnery oak stems were sampled from each plot. These lateral roots were 6 inches deep where branching occurs. The roots were placed in a drying oven (65C) for 48 hours. The roots were then cleaned with a rotation wire brush and ground in a Wiley Mill to pass through a 2 mm screen. The ground roots were then analyzed for % dry weight total non-structural carbohydrate (%TNC) by a modified anthrone method described by Shroyer (25).

To start the analysis, 0.5 gms of the ground sample was placed into a 300 ml beaker with 75 ml of 0.2N HCl. This mixture was allowed to boil slowly (98C) on a hot plate for one hour. The mixture was then filtered into a 100 ml volumetric and both beaker and the filtrate were washed by distilled water. The volumetric flask was then brought to volume and shaken to ensure mixing. Then 0.1 ml of the solution was then placed into a 20 ml test tube with 0.9 ml of distilled water, 5 ml of cold anthrone was added to the solution which was shaken with a Vortex mixer for 10 seconds. The test tube was then capped with a marble and placed into a hot water bath (100C). After 15 minutes in the hot water bath, the test tube was placed into a cold water bath for 20 minutes. The solution was then read for optical density on a spectrophotometer at 620 mu. All samples were measured against a standard curve prepared with a glucose-water mix. The standards used as a comparison at 0, 50, 100, 150, and 200 ug/ml. The treatments analyzed were the 10% picloram pellets at 1.12 and 2.24 kg/ha rates and the 3.2 mm diameter pellet of tebuthiuron at 0.56 and 1.12 kg/ha rates.

CHAPTER IV

RESULTS AND DISCUSSIONS

Control

1978 Aerial Study

Visual rating of the aerial plots taken in the fall of 1978 indicate good first year herbicidal activity with all treatments. Defoliation varied from 75% with the 0.56 kg/ha rates of tebuthiuron to 100% with the 2.24 kg/ha rate of 10% picloram pellets (Table 9). There were some significant differences amoung treatments by the second year. The highest canopy reduction, 96%, and stem kill, 92%, was with the 2.24 kg/ha rate of 10% picloram pellets. However, there were no significant differences between the 5 and 10% picloram pellets in canopy reduction, stem kill, or stem resprouts. There was a significant increase in brush control with the 2.24 kg/ha rate over the 1.12 kg/ha rate with both concentration of pellets. A significant decrease in stem resprouting was noted with the 2.24 kg/ha rate as compared to 81% with the 1.12 kg/ha rate.

The size of the tebuthiuron pellet had an influence on its activity. The canopy reduction in 1979, with the 3.2 mm pellet was significantly higher at both rates than with the smaller, 1.6 mm pellet diameter. There was also an increase of stem kill in 1979 with the larger pellet with the difference being significant at the 1.12 kg/ha rate. Stem kill

Table 9. Response of sand shinnery oak to aerial applied herbicides evaluated over three years.[a]

Treatment	ai[b]	Pellet size	Rate	First year defoliation	Second year control			Third year control		
					Can. red.	Stem kill	Basal sprouts[c]	Can. red.	Stem kill	Basal sprouts[c]
	(%)	(mm)	(kg/ha)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Picloram	10	4.0	1.12	80	62	42	81	32	18	83
Picloram	10	4.0	2.24	100	96	92	42	93	88	46
Picloram	5	4.0	1.12	80	61	51	55	30	15	80
Picloram	5	4.0	2.24	90	86	81	51	57	40	61
Tebuthiuron	20	3.2	0.56	75	62	41	74	47	28	76
Tebuthiuron	20	3.2	1.12	80	87	71	13	70	55	28
Tebuthiuron	20	1.6	0.56	75	34	19	68	39	19	89
Tebuthiuron	20	1.6	1.12	80	60	39	56	83	73	41
Check				0	16	8	85	8	2	100
$LSD_{0.05}$					25	28	32	21	21	28

[a] Data collected October 3, 1978, September 20, 1979, and October 6, 1980 respectively for first, second, and third year.

[b] Active ingredient.

[c] Percent of dead stems resprouting from crown area.

with the larger pellet was 71% while only 39% of the stems were killed with the smaller pellet. There was only 13% of the stems that resprouted with the large pellet compared to 56% that resprouted with the small pellets. Significant differences in canopy reduction, stem kill, and stem resprouts between rates of tebuthiuron was also noted the second year. These differences were all significant with the large pellets but only differences in canopy reduction was significant with the smaller pellet.

Both canopy reduction and stem kill, the third year were affected by concentration of picloram in the pellets. Canopy reduction was 93% with the 10% pellet and only 57% with the 5% pellet. There was also significant increase in canopy reduction and stem kill when a 2.24 kg/ha rate was used. Stem resprouts were also significantly reduced with the 2.24 kg/ha rate of picloram.

Increased activity was provided by the 1.12 kg/ha of both pellet size of tebuthiuron in the third year. Significant increases in canopy reduction and stem kill were noted for both sizes of pellets and so was the decrease in stem resprouting.

1978 Hand Broadcast Study

First year defoliation varied with formulation and rates of application (Table 10). The greatest defoliation, 98%, with the 2.24 kg/ha rate of 10% picloram pellets. However, there were no significant differences either in formulation or rates of application of picloram. The least defoliation, 20%, resulted with the 0.28 kg/ha rate of the 1.6 mm tebuthiuron pellet. The defoliation increased with the rate of tebuthiuron pellet. The defoliation increased as the rate

Table 10. Response of sand shinnery oak to hand broadcast herbicides applied in 1978 evaluated over three years.[a]

Treatment	ai[b]	Pellet size	Rate	First year defoliation	Second year control Can. red.	Second year control Stem kill	Second year control Basal sprouts[c]	Third year control Can. red.	Third year control Stem kill	Third year control Basal sprouts[c]
	(%)	(mm)	(kg/ha)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Picloram	10	4.0	1.12	84	85	77	79	77	68	69
Picloram	10	4.0	2.24	98	96	93	42	95	90	54
Picloram	5	4.0	1.12	76	64	56	50	62	51	72
Picloram	5	4.0	2.24	94	93	89	26	84	78	56
Tebuthiuron	20	3.2	0.28	61	45	24	34	32	18	89
Tebuthiuron	20	3.2	0.56	73	62	41	35	60	48	56
Tebuthiuron	20	3.2	1.12	88	98	90	17	83	76	47
Tebuthiuron	20	1.6	0.28	20	13	9	17	29	15	67
Tebuthiuron	20	1.6	0.56	73	59	38	53	63	52	50
Tebuthiuron	20	1.6	1.12	76	57	40	18	74	68	37
Vel 5026	10	4.8	0.56	74	80	63	44	86	79	48
Hexazinone	15	10 by 30	0.56	65	60	47	28	67	52	75
Check				0	11	7	13	21	8	100
$LSD_{0.05}$				21	24	27	39	27	28	30

[a] Data collected October 3, 1978, September 9, 1979, and October 6, 1980 respectively for the first, second and third year.

[b] Active ingredient.

[c] Percent of dead stems resprouting from crown area.

of tebuthiuron application increased. Canopy reduction and stem kill with the higher application rate of the 5% picloram pellet was significantly increased the second year but not the third year. Good stem kill, 93%, resulted with the 2.24 kg/ha rate of the 10% picloram pellets. This however, was not significantly better than the same pellet applied at a lower rate. Canopy reduction, and stem kill was with the 3.2 mm pellet of tebuthiuron at 1.12 kg/ha was 98 and 90% respectively with only 17% of the stems resprouting. This was significantly better than the 57% canopy reduction with the 1.6 mm pellet applied at the same rate.

By the third year, no differences in control between percent active ingredient or rates of applications of picloram were seen. With tebuthiuron, both canopy reduction and stem kill were increased by the rate of application increased. Canopy reduction and stem kill with the two sizes of tebuthiuron pellets were comparable by the third year. Canopy reduction and stem kill with Vel 5026 were comparable to the results with the 1.12 kg/ha rate of tebuthiuron. Results with hexazinone were comparable to the 0.56 kg/ha rate of tebuthiuron.

1979 Hand Broadcast Study

There was poor defoliation with all picloram treatments the first year of the study (Table 11). The highest defoliation with picloram 32%, resulted with the 2.24 kg/ha rates of both pellet sizes. No significant defoliation differences were noted between formulations, but there were some significant differences among rates. There was much better defoliation results with tebuthiuron. Defoliation increased from 57% at the 0.28 kg/ha rate to 78% at the 1.12 kg/ha rate, but this

Table 11. Response of sand shinnery oak to hand broadcast herbicides applied in 1979 evaluated over two years.[a]

Treatment	ai[b]	Pellet size	Rate	first year defoliation	Second year Can. red.	Second year Stem kill
	(%)	(mm)	(kg/ha)	(%)	(%)	(%)
Picloram	10	4.0	0.56	2	19	7
Picloram	10	4.0	1.12	23	47	27
Picloram	10	4.0	2.24	32	59	43
Picloram	10	2.4	0.56	13	35	16
Picloram	10	2.4	1.12	3	29	14
Picloram	10	2.4	2.24	32	55	31
Tebuthiuron	20	3.2	0.28	57	56	24
Tebuthiuron	20	3.2	0.56	60	75	38
Tebuthiuron	20	3.2	1.12	78	86	56
Hexazinone	10	10 by 30	0.56	67	65	34
Check				3	7	3
$LSD_{0.05}$				25	19	14

a Data taken September 20, 1979, and September 24, 1980 respectively for the first and second year.

b Active ingredient.

difference was not significant.

Canopy reduction and stem kill increased as the rate of picloram increased with both pellet sizes. Pellet sizes of picloram has no significant effect on canopy reduction or stem kill. The best canopy reduction and stem kill resulted with the 1.12 kg/ha rate of tebuthiuron.

1980 Hand Broadcast Study

Defoliation results are listed in Table 12. Defoliation with picloram was 50% with the 2.24 kg/ha and only 27% with the 1.12 kg/ha rate. First year defoliations with the tebuthiuron treatments were better. The defoliations with the 10% pellet were consistantly better than the 20% pellet, but none of the differences were significant. Also, the percent defoliations increased as the rate increased but again none of the differences were significant.

Root TNC Levels

1978 Hand Broadcast Study

All treatments significantly reduced the TNC levels in the roots below that of the untreated plants by September, 1979 (Table 13). At the first harvest date, September, 1979, the TNC levels in the roots of plants from picloram and tebuthiuron plots were significantly lower than those from the untreated plants. There was also no increase in TNC levels in roots from plants in the treated plots from September to November whereas TNC levels in roots from the untreated area increased from 19.4% in September to 25.7% by November. There were no signifi-

Table 12. Response of sand shinnery oak to hand broadcast herbicides applied in 1980 and evaluated for one year.[a]

Treatment	ai	Pellet size	Rate	First year defoliation
	(%)	(mm)	(kg/ha)	(%)
Picloram	10	4.0	1.12	27
Picloram	10	4.0	2.24	50
Tebuthiuron	20	3.2	0.56	47
Tebuthiuron	20	3.2	1.12	65
Tebuthiuron	20	3.2	1.68	63
Tebuthiuron	10	3.2	0.56	53
Tebuthiuron	10	3.2	1.12	73
Tebuthiuron	10	3.2	1.68	83
Hexazinone	10	10 by 30	1.12	78
Hexazinone	10	10 by 15	1.12	88
Check				8
$LSD_{0.05}$				30

[a] Data taken September 24, 1980.

cant difference among herbicide treatment effects in September or November of 1979. The TNC levels of the existing plants in the treated plots by 1980 were still lower than the untreated plants but not all of the decreases were significant. In July there was 16.5% TNC in roots with the 0.56 kg/ha rate of tebuthiuron and this was not significantly lower than the untreated plants. The TNC levels in roots of plants from plots treated with 1.12 kg/ha of tebuthiuron and with both rates of 10% picloram pellets were still significantly lower than the untreated plants. No significant difference in TNC levels were found in any of the roots at the September and December 1980, harvest dates. This would indicate that the treatments are no longer having a significant effect on the remaining plants.

1979 Hand Broadcast Study

First year and second year data were taken on the 1979 study to determine how soon the treatments had influences on TNC levels in the roots (Table 14). One month after application there was a significant decrease in % TNC levels associated with the 2.24 kg/ha rate of 10% picloram pellets. By September the TNC level in the roots from plots treated with 1.12 kg/ha of picloram were significantly lower than the check but levels in the roots from the higher rate were not different. These differences are not explainable but defoliation readings were only 23% for the 1.12 kg/ha rate and 32% for the 2.24 kg/ha rate. This is low activity compared to results in earlier studies. This is further magnified by the fact that no significant reduction in TNC was seen in the second year.

Tebuthiuron exerted its effects on the TNC levels in the roots

Table 13. Root TNC levels for the 1978 hand broadcast study.

Treatment	ai	Pellet size	Rate	Harvest dates Sept 79	Nov 79	July 80	Sept 80	Dec 80
	(%)	(mm)	(kg/ha)	(%)				
Picloram	10	4.0	1.12	11.9	8.2	14.4	23.3	18.1
Picloram	10	4.0	2.24	10.8	6.8	12.4	20.9	17.3
Tebuthiuron	20	3.2	0.56	12.9	10.7	16.5	20.9	15.5
Tebuthiuron	20	3.2	1.12	9.1	8.9	13.7	19.2	13.8
Check				19.4	25.7	22.6	24.6	19.7
$LSD_{0.05}$				4.5	5.3	6.7	NS	NS

Table 14. Root TNC levels for the 1979 hand broadcast study.

Treatment	ai	Pellet size	Rate	Harvest dates July 79	Sept 79	July 80	Sept 80	Dec 80
	(%)	(mm)	(kg/ha)	(%)				
Picloram	10	4.0	1.12	14.2	13.0	10.4	13.3	16.2
Picloram	10	4.0	2.24	8.6	15.1	10.4	13.3	16.4
Tebuthiuron	20	3.2	0.56	10.7	16.8	7.7	12.5	9.2
Tebuthiuron	20	3.2	1.12	10.1	13.4	4.0	7.9	12.4
Check				13.9	15.9	15.2	17.8	18.9
$LSD_{0.05}$				4.7	2.8	5.2	6.5	7.6

much slower. There were no significant reductions the first year, but by the second year there were significant reductions by both rates. These reductions were significant in the months of July and December at the 0.56 kg/ha rate and significant at all three sampling dates at the 1.12 kg/ha rate.

1980 Hand Broadcast Study

A December harvest date was used for the 1980 study to determine first year effects (Table 15). The TNC levels in the roots were significantly reduced by both rates of tebuthiuron and by the 2.24 kg/ha rate of picloram.

Forage Yields

1978 Aerial Study

There were no significant increases in total grasses or total forage production the first year (Table 16). Forb production was significantly decreased by all treatments with the exception of the large tebuthiuron pellet at the 0.56 kg/ha rate. There was a significant increase in the amount of Bouteloua gracilis over the check areas with the 2.24 kg/ha rate of 10% picloram pellet. There was also a significant increase in the amount of Andropogon hallii above that of the check areas with the 2.24 kg/ha of 5% picloram pellets.

Total grass production the year after the treatments were applied was significantly increased by all treatments with the exception of the large tebuthiuron pellet at 1.12 kg/ha (Table 17). There were no significant differences in the amount of forbs produced with the

Table 15. Root TNC levels for the 1980 hand broadcast study.

Treatment	ai	Pellet size	Rate	Harvest date Dec 80
	(%)	(mm)	(kg/ha)	(%TNC)
Picloram	10	4.0	1.12	15.0
Picloram	10	4.0	2.24	9.2
Tebuthiuron	20	3.2	0.56	10.6
Tebuthiuron	20	3.2	1.12	9.4
Check				17.9
$LSD_{0.05}$				5.5

Table 16. 1978 forage yields for the 1978 aerial applied herbicide study.[a]

				Forage classes										
Treatment	ai[b]	Pellet size	Rate	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Other Grasses	Total Grasses	Forbs	Total Forage
	(%)	(mm)	(kg/ha)	(kg/ha)										
Picloram	10	4.0	1.12	85	42	77	321	44	72	75	96	810	17	828
Picloram	10	4.0	2.24	136	55	32	203	48	99	68	122	762	11	773
Picloram	5	4.0	1.12	86	60	57	379	66	96	47	58	636	22	658
Picloram	5	4.0	2.24	77	57	46	369	131	108	24	41	870	0	854
Tebuthiuron	20	3.2	0.56	39	28	79	287	66	69	46	64	678	42	720
Tebuthiuron	20	3.2	1.12	61	46	38	285	29	70	48	58	636	22	658
Tebuthiuron	20	1.6	0.56	85	42	77	321	44	72	75	96	810	17	828
Tebuthiuron	20	1.6	1.12	82	44	60	346	58	68	51	72	781	7	788
Check				23	26	58	371	39	50	52	66	685	89	774
LSD 0.05				100	NS	NS	NS	76	NS	NS	34	NS	53	NS

[a] Data taken on July 12, 1978.

[b] Active ingredient.

Table 17. 1979 forage yields for the 1978 aerial applied herbicide study.[a]

				Forage classes										
Treatment	ai[b]	Pellet size	Rate	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Other Grasses	Total Grasses	Forbs	Forage
	(%)	(mm)	(kg/ha)	(kg/ha)										
Picloram	10	4.0	1.12	113	99	117	492	48	114	123	340	1447	101	1548
Picloram	10	4.0	2.24	200	88	23	547	41	108	100	46	1560	122	1683
Picloram	5	4.0	1.12	157	122	69	529	116	184	82	209	1468	151	1620
Picloram	5	4.0	2.24	145	128	36	732	90	241	45	225	1640	218	1858
Tebuthiuron	20	3.2	0.56	47	48	145	578	48	78	90	168	1201	193	1394
Tebuthiuron	20	3.2	1.12	96	128	76	460	11	23	85	204	1089	91	1180
Tebuthiuron	20	1.6	0.56	61	144	83	576	32	63	126	248	1334	133	1466
Tebuthiuron	20	1.6	1.12	72	135	39	473	53	142	91	225	1231	94	1325
Check				25	50	77	389	6	39	53	107	577	131	887
$LSD_{0.05}$				170	58	NS	NS	70	112	67	NS	517	NS	572

[a] Data taken on July 18, 1979.

[b] Active ingredient.

various treatments. The only tebuthiuron treatment which significantly increased the amount of total forage produced was the small tebuthiuron pellet at the 0.56 kg/ha rate.

All picloram treatments significantly increased the amount of total forage produced above 887 kg/ha produced by the check plot. The most forage production, 1858 kg/ha, was from plots treated with the 2.24 kg/ha rate of 5% picloram pellets. Sporobolus cryptandrus, Andropogon hallii, Panicum virgatum, and Paspalum stramineum were the species that increased when sand shinnery oak was controlled.

Forage production was somewhat lowered in 1980 possibly due to the extremely hot dry winds and low amounts of rainfall (Table 8). The 5% picloram pellet at 2.24 kg/ha was the only herbicide treatment to significantly increase the total grass production and total forb production (Table 18). Both of the 5% and 10% picloram treatments at 2.24 kg/ha significantly increased the amount of total forage produced. There was also an increase in total forage production with both rates of the small pellets of tebuthiuron with differences being significant at the 0.56 kg/ha rate. Bouteloua gracilis and Sporobolus cryptandrus responded favorably to the picloram treatments. There was a significant increase in Eragrostis trichodes with the 3.2 mm tebuthiuron pellet.

1978 Hand Broadcast Study

Forage yields the year following treatment are listed on Table 19. The 5% picloram pellet at 1.12 kg/ha was the only treatment where an increase in the amount of total grasses resulted. The biggest response for this treatment was the release of Andropogon scoparius. This

Table 18. 1980 forage yields for the 1978 aerial applied herbicide study.[a]

				Forage classes										
Treatment	ai[b]	Pellet size	Rate	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Other Grasses	Total Grasses	Forbs	Total Forage
	(%)	(mm)	(kg/ha)	(kg/ha)										
Picloram	10	4.0	1.12	55	31	37	191	40	22	14	60	451	97	547
Picloram	10	4.0	2.24	74	43	28	278	75	56	14	77	645	106	751
Picloram	5	4.0	1.12	75	51	18	274	31	30	10	34	525	103	628
Picloram	5	4.0	2.24	52	26	30	376	150	77	9	25	740	176	920
Tebuthiuron	20	3.2	0.56	21	25	32	374	35	69	20	20	596	97	693
Tebuthiuron	20	3.2	1.12	30	43	72	216	4	30	14	40	486	82	568
Tebuthiuron	20	1.6	0.56	27	34	30	451	65	30	8	31	675	69	744
Tebuthiuron	20	1.6	1.12	24	35	2	430	47	43	24	38	642	87	729
Check				15	24	25	220	76	42	16	26	444	42	486
$LSD_{0.05}$				54	25	45	NS	NS	NS	NS	NS	251	84	256

[a] Data taken on July 16, 1980.

[b] Active ingredient.

Table 19. 1979 forage yields for the hand broadcast study applied in 1978.[a]

				Forage classes										
Treatment	ai[b]	Pellet size	Rate	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Other Grasses	Total Grasses	Forbs	Total Forage
	(%)	(mm)	(kg/ha)	(kg/ha)										
Picloram	10	4.0	1.12	6	22	215	835	0	0	59	125	1271	210	1482
Picloram	10	4.0	2.24	34	21	14	1200	57	181	23	125	1654	50	1704
Picloram	5	4.0	1.12	1	6	39	1462	55	139	10	276	1987	130	2117
Picloram	5	4.0	2.24	94	13	6	604	18	107	60	125	1026	60	1086
Tebuthiuron	20	3.2	0.28	0	6	16	920	9	38	18	106	1113	74	1187
Tebuthiuron	20	3.2	0.56	61	34	35	1152	264	82	50	141	1824	97	1921
Tebuthiuron	20	3.2	1.12	44	64	95	635	0	70	66	29	1272	195	1467
Tebuthiuron	20	1.6	0.28	2	11	16	1199	67	63	30	158	1546	30	1576
Tebuthiuron	20	1.6	0.56	0	44	16	486	43	177	27	103	896	43	939
Tebuthiuron	20	1.6	1.12	22	53	8	752	0	315	92	478	1721	116	1837
Vel 5026	10	4.6	0.56	14	31	40	684	78	43	47	124	1060	122	1181
Hexazinone	15	10 by 30	0.56	76	57	45	458	4	56	27	161	878	183	1061
Check				11	6	25	583	34	32	43	108	842	147	990
$LSD_{0.05}$				74	52	124	872	206	NS	NS	259	1090	NS	1108

[a] Data taken July 18, 1979.

[b] Active ingredient.

picloram treatment was also the only treatment which significantly increased the total forage production. There were some forage increases in the picloram plots with *Andropogon scoparius*, *Bouteloua gracilis*, and *Eragrostis trichodes*.

The amount of total forage production was increased by both formulations at the 2.24 kg/ha rate. The total forage production in plots treated with 2.24 kg/ha of 10% picloram pellets were triple that of the check areas. Both the 5% and 10% pellets of picloram increased total grass production the third year when applied at a 2.24 kg/ha rate (Table 20). This increase was due largely to the significant release of *Andropogon scoparius*. Total forb production was also increased by both formulations at the 2.24 kg/ha rate. Tebuthiuron, Vel 5026, and hexazinone were comparable to each other when looking at total grass production and total forage production significantly higher forb production is noted for Vel 5026 and hexazinone in the third year.

Table 20. 1980 forage yields for the hand broadcast study applied in 1978.[a]

								Forage classes						
Treatment	ai[b]	Pellet size	Rate	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Other Grasses	Total Grasses	Forbs	Total Forage
	(%)	(mm)	(kg/ha)	(kg/ha)										
Picloram	10	4.0	1.12	13	7	63	681	71	26	15	23	899	98	996
Picloram	10	4.0	2.24	13	5	5	1569	161	150	0	28	1930	91	2022
Picloram	5	4.0	1.12	0	0	13	1032	117	51	3	12	1228	98	1325
Picloram	5	4.0	2.24	17	1	0	1145	15	134	34	47	1392	172	1563
Tebuthiuron	20	3.2	0.28	39	16	54	602	170	110	5	30	1027	68	1095
Tebuthiuron	20	3.2	0.56	12	17	38	685	168	148	24	69	1162	58	1220
Tebuthiuron	20	3.2	1.12	74	14	16	485	0	26	11	51	678	36	916
Tebuthiuron	20	1.6	0.28	0	0	28	680	58	12	8	52	949	26	975
Tebuthiuron	20	1.6	0.56	0	19	66	505	230	17	19	37	893	74	967
Tebuthiuron	20	1.6	1.12	32	5	41	492	16	168	25	99	874	60	934
Vel 5026	10	4.8	0.56	55	14	0	628	40	0	5	81	775	152	927
Hexazinone	15	10 by 30	0.56	39	32	38	446	18	34	19	27	652	146	798
Check				28	0	3	412	44	118	15	24	643	23	666
$LSD_{0.05}$				NS	21	NS	626	NS	NS	NS	NS	746	84	718

[a] Data taken on July 16, 1980.

[b] Active ingredient.

CHAPTER V

SUMMARY

Field research studies were conducted to determine the effect of pelleted herbicedes on control of sand shinnery oak and forage release associated with control. Defoliation results with the 2.24 kg/ha rate of the 10% picloram pellets were very good with both studies applied in 1978. Canopy reduction and stem kill of better than 90% were still seen three years after application. Canopy reduction and stem kill with the 5% pellet were varible three years after application. There was also less resprouting associated with the 10% pellets. However, stem resprouts were not adequately controlled by any formulation or rates of picloram. Where applications are made in late spring or early summer, picloram's ability is greatly reduced. Defoliation readings from both the 1979 and 1980 studies indicate the reduction in activity.

Tebuthiuron is more consistent than picloram in time of application. Differences in pellet size were very small. Rate of application has the biggest effect on control. The 1/12 kg/ha rate is significantly higher than the other rates of application. Tebuthiuron provided better control of stem resprouts than picloram. Control of resprouts was deminishing after three years of activity, however.

Forage yields were increased the year following application of the pelleted herbicides. Total forage production was high with picloram than tebuthiuron in the second year and third year, however tebuthiuron provided better control of forbs that were produced. Significant yield increases were seen with tebuthiuron when applied as the smallest pellet at the lowest rate. This might suggest that tebuthiuron does exert some detrimental effects on the native grasses. Vel 5026 and hexazinone are comparable to tebuthiuron, however these herbicides do not control forb production as well.

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